

The second Gulf of Mexico & East Coast Carbon (GOMECC-2) cruise is underway,

The second Gulf of Mexico & East Coast Carbon (GOMECC-2) is taking place to perform a large-scale survey of ocean acidification trends and dynamics in the Gulf of Mexico and East Coast of the USA on NOAA ship Ronald H. Brown from July 21 through August 13. Twenty-two scientists from seven different institutions are participating in the effort. The survey includes 8 cross-shelf transects where the full water column will be measured for a comprehensive suite of biogeochemical parameters that affect or are affected by ocean acidification. Between transects the ship will take extensive measurements of surface water conditions with highly automated instruments sampling the coastal ocean predominantly at depths between 30 and 100m. Further details on operations, participating institutions and cruise track can be found at <http://www.aoml.noaa.gov/ocd/gcc/GOMECC2/>

It seems like distant past when we left Miami. After a trying and costly loading in the Port of Miami, NOAA ship Ronald H. Brown sailed out of Government Cut at noon Saturday July 21. During the in-port the rules and regulations of port access got stricter by the hour. A crane and a full crew of stevedores had to be hired at the last minute to load two containers onto the ship, as the ship's crane was not allowed to be used. During the second day of loading only government vehicles were allowed on the pier such that we were left with loading the gear from the rental trucks that arrived from Mississippi and Georgia into a government vehicle outside the gates to get the equipment ship-side and lug each crate up the gangplank. Just what the members of the scientific party wanted to do after a very long drive..... But all was dealt with ingenuity and good cheer.

Setup went very well and all instruments were set up and secured, and many working by the time we left. Several of us had bouts of "mal de mer" for the first day despite relatively calm seas. An inquiry if the seas were considered moderately rough drew snickers from the more seasoned scientists and crew. By Monday morning the seas calmed even more and mess hall was filled. Weather has been great since with calm seas.

The number of instruments and technologies to study ocean acidification in the East coast and Gulf Coast realm is impressive. Instruments range from those performing state-of-the-art analyses to the highest accuracy to very novel ones. Many are set up around the spigot of the uncontaminated seawater line in the hydro lab. They include the underway pCO₂ system that has been a permanent installation measuring surface water pCO₂ levels wherever the BROWN sails. For this cruise these measurements have been augmented with the Multi-parameter Inorganic Carbon Analyzer (MICA) from the University of South Florida that measures total inorganic carbon, pH, and pCO₂. The "barrel of optics" from the University of New Hampshire is situated in a large drain pan. This is a large barrel with continuous water feeds that include an oxygen sensor, fluorometer, spectrophotometers, and a transmissometer. Most of the optics are used to determine biological parameters and processes in the ocean.

Sampling at depth is done using special 10 liter bottles that can be closed at designated depths (Niskin bottles). The frame holds 24 bottles and includes instruments to measure conductivity (salinity), temperature and depth (CTD), and oxygen. For GOMECC-2 5 different optical sensors are included. These parameter are monitored when the package goes down to get a first look at

biogeochemical features and physical structure of the water column. These traces are used to determine at what depth samples will be taken. A novel profiling spectrophotometric pH meter is strapped to the frame as well. The instrument can resolve the depth structure of pH at a resolution to 2 m.

The fun really starts when the CTD and bottles come back on deck and we descend as hyenas on a cadaver to subsample the Niskins for a favorite parameter. A pecking order has been established on sequence of subsampling based on possibility of sample degradation and contamination.

We started the 100-mile Mississippi line of CTD/Niskin profiles on Monday evening and just completed 11 stations in the wee hours of Wednesday morning. It was 36 hours of non-stop action. An added challenge was the many drilling rigs and support ships that are in the region. The depth of the water near-shore was less than 20 m and it felt like the ship was transiting through a big city, particularly at night when the oilrigs are lit up like Christmas trees.

This first CTD transect went very well. The depth profiles showed strong interleaving of relatively high oxygen values with much lower values that we suspect are coming from the low oxygen “dead zones” near the coast of Mississippi. Our last three shallow stations were parallel to the coast through the area where the dead zone of low oxygen waters develops each summer. Initial analyses suggest levels close to hypoxia below 15 m in the region and we are awaiting the analyses of carbon parameters and pH. One of our scientific objectives is to determine the correlation of low oxygen with the parameters affecting ocean acidification and we should have ample samples to study this further.

Our steam and dream transit to the Tampa CTD section just got interrupted by a fire alarm because of smoke in the engine room that was associated with an electrical generator failure. Because we are operating around the clock many were rudely awakened and there were many sleepy scientist mustering in the science lab. Our fire drill right after departure came to good use and all followed proper procedure. The generator issue is under control but command and crew are busy getting all systems back up after a shipwide electrical blackout associated with the failure.

Never a dull moment
Rik and Leticia,
Chief scientists GOMECC-2



Picture of the fantail of the Brown off the coast of Mississippi with oil rigs in the background Wednesday Jul 24. The CTD with Niskin bottles and pH profiler strapped to the side is in the foreground. (courtesy Andrew Margolin)

GOMECC-2 Update #2: Voted off the ship

The first 10 days of the second Gulf of Mexico & East Coast Carbon (GOMECC-2) went very well. Seas have been calm, the many sophisticated instruments are behaving well, and operations are proceeding smoothly. The efficient execution of the science and good ship speed even allowed for a short shore-side excursion.

Scientist, officers and crew are all engaged in operations and are showing great interest in the project objectives. However, it became apparent that our presentation about ocean acidification given to the crew might have been overdramatized when a crewmember mentioned that he had dreamed that the whole ocean had turned into carbonated soda pop and he was trying to drink it. He commented: “ It tasted like Sprite- and I don’t even like Sprite”.

After finishing the CTD transect off the coast of Mississippi, we followed the coastline towards the big bend region of Western Florida (for a cruise track see the attached figure). We crossed the outer edges of the Mississippi river plume that showed the effects of biological productivity with low surface water carbon levels and higher pH than surrounding waters. Once beyond this region the coastal ocean acted as a variable but strong CO₂ source to the atmosphere.

The cruise then proceeded offshore for the start of the Tampa/St Petersburg line several hundred miles offshore in water depths of about 2 miles and proceeded to a few miles off the coast in depths less than 60 feet. The deep-water chemistry changes are very small over time and the measurements are used, in part, to check how well the instruments perform. Our preliminary results show almost identical values for biogeochemical and physical parameters as our previous cruise in 2007 in deep water giving added confidence that changes we are seeing closer to the surface are real. Surface parameters are showing significant differences and high variability. While the variability far offshore was at first puzzling satellite imagery of chlorophyll, sea surface height, and particular sea surface temperature showed appreciable small-scale changes. The satellite imagery provided to us by the NOAA Coastwatch Caribbean/Gulf of Mexico Regional Node (<http://cwcarribbean.aoml.noaa.gov/data.html>) and other sources offers the unique opportunities to put our observations into regional context and to provide a means to interpolate our data over larger scales. Other opportunities to obtain greater coverage are the sensors we place on ships of opportunity. By following our progress on the NOAA ship tracker site (<http://shiptracker.noaa.gov/shiptracker.html>) which is updated hourly with ship location and key surface measurements, we noticed that we were within 50 miles of NOAA ship Gordon Gunter that plies the waters of the GoM year round on which we have automated instruments. Combining these data sources will provide a great ocean acidification dataset for the region

A major goal of our measurements is to obtain a more detailed characterization of the chemical parameters that impact ecosystems. Most of the efforts to date have looked at how bulk carbon parameters such as pH, total inorganic carbon and alkalinity are affecting growth of organism but laboratory studies suggest that individual chemical species have an impact. Thus besides measuring the bulk inorganic carbon parameter participants from the University of Georgia are taking samples for Calcium a major building block for shells and the University of South Florida team are providing measurements of carbonate ion concentrations, which is critical for shell formation as well. All in all we take up to 15 different measurements from each depth samples.

Each measurement requires different containers and it is quite a site around the Niskin CTD Rosette with Siskins when the cast comes up with boxes filled with glass bottles of different shapes and sizes, plastic bottles ranging in size from 2 gallons to 2 ounces and pricey spectrophotometer cells.

We got a pleasant reward for our hard and efficient work and fast progress by an unexpected stop of several hours at Fort Jefferson in the Dry Tortugas. A small boat ferried us to the island for a tour of the fort and swimming and snorkeling opportunities in the pristine waters. Of course, all the while our automated instruments were taking measurements on board so no science time was wasted!

The last notable event in this weekly report is that we copied popular TV series with an “off the ship vote”. Much to my consternation I (Rik W) received most votes and together with Kyle Seaton were sent packing to Miami. Our division director, Dr. Michelle Wood is taking over as chief scientist and will lend her expertise on phytoplankton growth and ecology to the effort. I’m back in the office and will follow the ship from afar while it makes its way up the East Coast.

Rik & Leticia, Chief Scientists

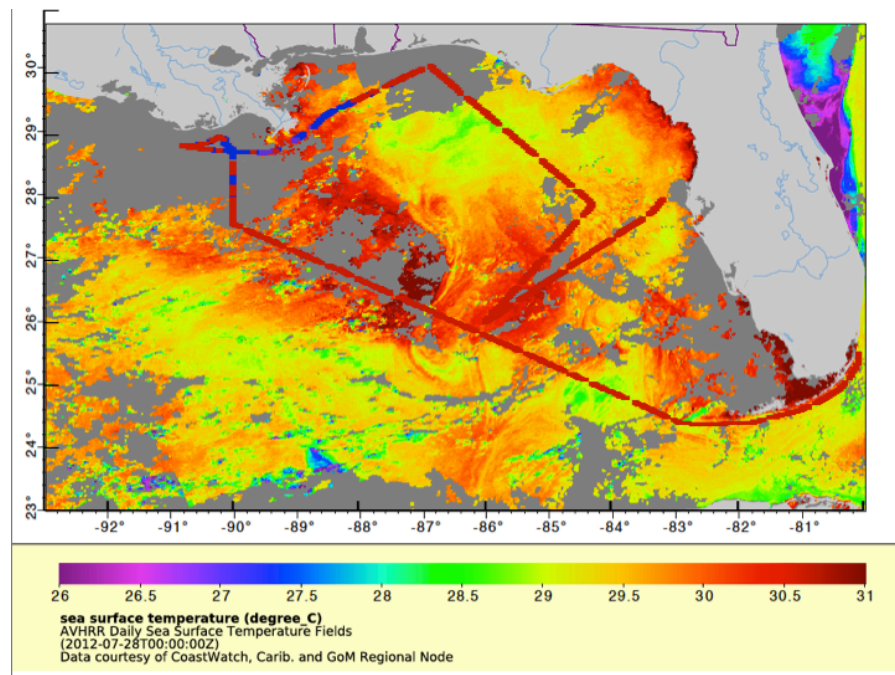


Figure:

Cruise track superimposed on a satellite sea surface temperature (SST) image. The variability and fine structure seen in the SST was also reflected in the biogeochemical measurements. The cruise track is shown in red and blue where the red line indicated that the area was a CO₂ source with relatively low pH, and the blue line indicates a CO₂ sink (higher pH). The sink areas are in the Mississippi effluent whose nutrient laden waters enhance productivity in the surrounding ocean and lower CO₂ levels.

GOMECC-2 Cruise Update #3

The personnel transfer when Rik got off and I got on seems like so long ago, but it was a beautiful day there off of Miami, and we have continued to have fair weather and easy seas, which has meant for clear skies when we collect above-water radiances for our collaboration with the NPP VIIRS cal/val team and excellent conditions for station deployments and lab work. In a few hours we will begin the first station of the 'W' line that extends from nearshore (~45m) off Cape Cod and extends to >4000m where we will collect samples that provide calibration information for our sensors and additional hard-to-get data for Western Boundary Studies. I want to particularly thank Lt. Rachel Kotkowski for her excellent command of AOML's R/V Hildebrand during the personnel transfer and scientists Mark Emond and Sumit Chakraborty on the ship for their participation in the data collection for the NPP cal/val.

Our transect off of the LEO-15 site consisted of five nice stations in shelf waters (25-50m), with boundary conditions established by a shelf-break station (100m), and two deeper stations (1300 and 2400m). During transit to this line we noticed a lot of unusual variability in the underway salinity record provided by the ship's TSG sensor. Subsequence comparisons of the data from this sensor with TSG sensors on the pCO₂ system confirmed the existence of a problem but replacement of the ship's TSG sensor with a new one, and extensive investigation of the communication system reporting data from the ship's TSG has not yet identified the problem. For underway records, we have switched to recording data from the pCO₂ system. It is possible that the problems with the ship's TSG are a result of running the system in turbid water off the Mississippi River, although similar issues do not seem to be arising with the pCO₂ system.

Our first two transects of this leg of the cruise were the Western Boundary transect from ~Jupiter, FL to the Bahamas, and a transect off Georgia. In between these lines, we transited along the 50m contour with underway sampling every two hours. Satellite imagery from the Ocean Optic group at NRL and input from Mitch Roffer alerted us to the presence of very low temperature water on the shelf between Cape Canaveral and Jacksonville. The satellite data showed that we probably sampled the eastern edge of this cool water. Underway pCO₂ and temperature sensors showed substantial variability over relatively short time intervals as we transited the coast along the Fla/Ga border, suggesting we were encountering filaments along the edge of the feature. We have appreciated all the remote sensing support we have received through NRL Ocean Optics and NOAA Coastwatch.

The highlight of the Georgia Line was the successful communication with the Gray's Reef pCO₂ buoy coordinated by Sylvia Musielewicz of PMEL. Shortly before we occupied station near the buoy it began a 24 hour period of hourly sampling and we were able to monitor water conditions for slightly over three hours, serendipitously capturing data for a time period that included four of the buoy's six-minute

observing periods. We have another 'buoy occupation site' coming up at the end of the cruise off of New Hampshire.

We have had relatively few problems with other instruments. The CTD water sampler failed altogether at Station 43 (30 50.8N, 79 25.7W, 810m), after signaling some problems by failing to advance the bottle count after some bottles were fired. Efforts are underway to double-check data from those earlier 'warning' stations to be sure bottles that may have tripped at the wrong depth are clearly identified. The water sampler was replaced quickly and efficiently by Andy Stefanick, Jay Hooper working with Chief Survey Technician Johnathan Shannahoff and Electronics Technician Clay Norfleet, and the cast repeated so all planned water samples were collected.

In addition to the nice weather, wildlife interactions have enriched our days. The most recent encounter is a small bat that joined the ship off of New Jersey. A few days ago a Brown Booby spent considerable time resting on the instrument frame at the bow of the ship, and soaring along the bow feeding on flying fish. Even more exciting was the Wahoo dinner we had a few days ago, courtesy of expert fishers (and fish cleaners) among the crew and science party.

Arrival in Boston is looking like mid- to late afternoon on the 13th, with a lot of samples to process as we come off the New Hampshire line. We do seem on track to complete all planned sampling, thanks to the diligent efforts of FOO Paul Chamberlain, CO Mark Pickett and all the crew to work with us in meeting our science goals as efficiently as possible. Right now, people are in pretty good shape overall although several groups have indicated that sample bottles were not sufficient to cover both the underway and station samples. It is not clear if this was a problem with advance planning or not, but it something to consider before the next cruise of this sort. In the meantime, all hands are doing a great job of reporting data with more than 50% of all preliminary data already in the data managers' hands and many groups completely up-to-date. This allows Rik to sit in Miami and ponder the meaning of it all as it comes to him over the internet.

Michelle Wood, Chief Scientist

Leticia Barbero, Co-Chief Scientist

GOMECC-2 Cruise Update # 4

Aug. 12 – 8AM

GOMECC-II approaches the end, with clear changes in mood and energy and topics of discussion as we begin to think about the offload, and timing of final casts. While the steaming time from our last station to the Boston sea buoy is not particularly long, and we appear to be on time so far, there are also key considerations regarding the time needed to process all the samples we've collected since stating the New Hampshire line at 10PM last night, and allowing for equilibration time – which can be as long as 12 hours before some samples can be run.

We will be docking in MASSPORT (Black Falcon) during the slack tide on Tuesday afternoon (~3PM) according to the current plan and – so far – the timing looks good for our final 24 hours of sampling. This morning at dawn we had arrived at Station 85, which is conveniently located in the 'median' of the entrance to the traffic separation lane for the Boston entrance. We are currently transiting about 2 hours to Station 86 which is in the median of another traffic separation zone for the northern access to Boston.. From there we move into the middle of the Northern Right Whale sanctuary in the Gulf of Maine as we steam toward Station 87. These stations have given cause for further admiration and appreciation of the safety consciousness and excellent navigation by the command - and the dedication of Capt. Pickett and his crew to us getting our work done. In addition to ships, tugs with tows, and fishing boats, today promises some encounters with more wildlife – there was already a whale sighting at the dawn station (which was also a beauty with pink fish scale skies and a golden sunrise).



Picture courtesy of our Field Ops. Officer, LT. Paul Chamberlain

Weather for today is looking a bit like some misty New England rain at our next station, and noticeably cooler temperatures than the last few days. We have also had higher seas and more swells for the past 36 hours than any time before on this leg of the cruise. There were scattered white caps and repeated wind rows of *Sargassum* all day yesterday as we came inshore from Station 82 at the end of Line W. However, overall, the weather has really facilitated GOMECC-II research. I once heard Dick Barber has described the Atlantic as a 'nervous little ocean' but, for us, it has been more pacific than the Pacific.

So far, we have been able to complete all planned stations, including the deepest casts on Line W, and we were also able to add a few shallow stations at the beginning of the Chesapeake and LEO lines. Assuming success at completing all the New Hampshire stations, we will have achieved 108% of planned stations and analyzed over 1300 samples. In addition, CDOM, pigment, DOC, and a few other types of samples are going off the ship for subsequent analysis in various labs. We have done optical measurements for the NPP/VIIRS cal/val at about 23 stations, mostly during the afternoon. Data reporting to the data managers continues to be excellent, both for underway and CTD casts. The one disappointment here at the end of the cruise is the fact that an instrument problem means that the UNH CO2 buoy will not be in place when we complete the New Hampshire Line so we will not be holding station there for intercalibration. We hear it will be out there soon, though, probably this week!

We have not had any onboard instrument problems since our last weekly report, except for an easy-fix issue with the profiling pH meter. We have had a few issues with the water budgets on the deep casts, where every bottle was tripped at a different depth and we could not trip any duplicates. Getting enough water for the big-draw bottles where oxygen, nutrients, salts, pigments, and all forms of carbon samples were collected was sometimes hard. This led to a variety of approaches to 'encouraging' water conservation – including red tape on the high-demand bottles to regular and frequent warnings by the "Bottle Cops", Leticia and Michelle.

One surprise on this cruise is the fact that not one Styrofoam cup went down with the CTD, even though we went to >4000m at least twice and >>2000m seven times on Line W. Discussions were held, and a suggestion made for the ship's store to stock the requisite cups and colored pens, but – in the end- we have no tiny little colored cuplets to take home for our friends. I have to say, though, as a newly re-trained CTD console person there is a definite rush associated with watching the altimeter approach 10m above bottom when you have >4000m of wire out. I found I was not actually brave enough to try for a 'Winch stop' at 5m, I'll leave that to the guys from PhOD.

Michelle Wood, Chief Scientist

Leticia Barbero, Co-Chief Scientist